Future Missions Concepts for The Exploration of the Solar System

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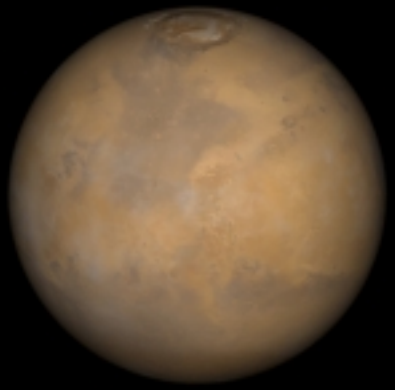
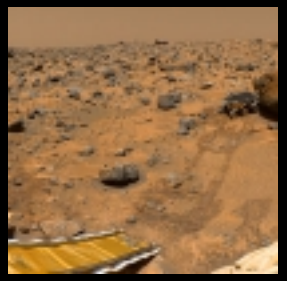
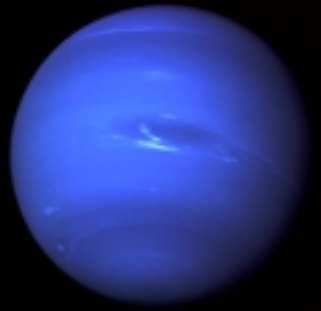
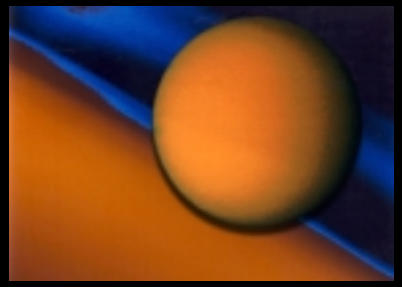
Solar System Exploration Programs

Mars Exploration Program:
Bringing Mars to Earth







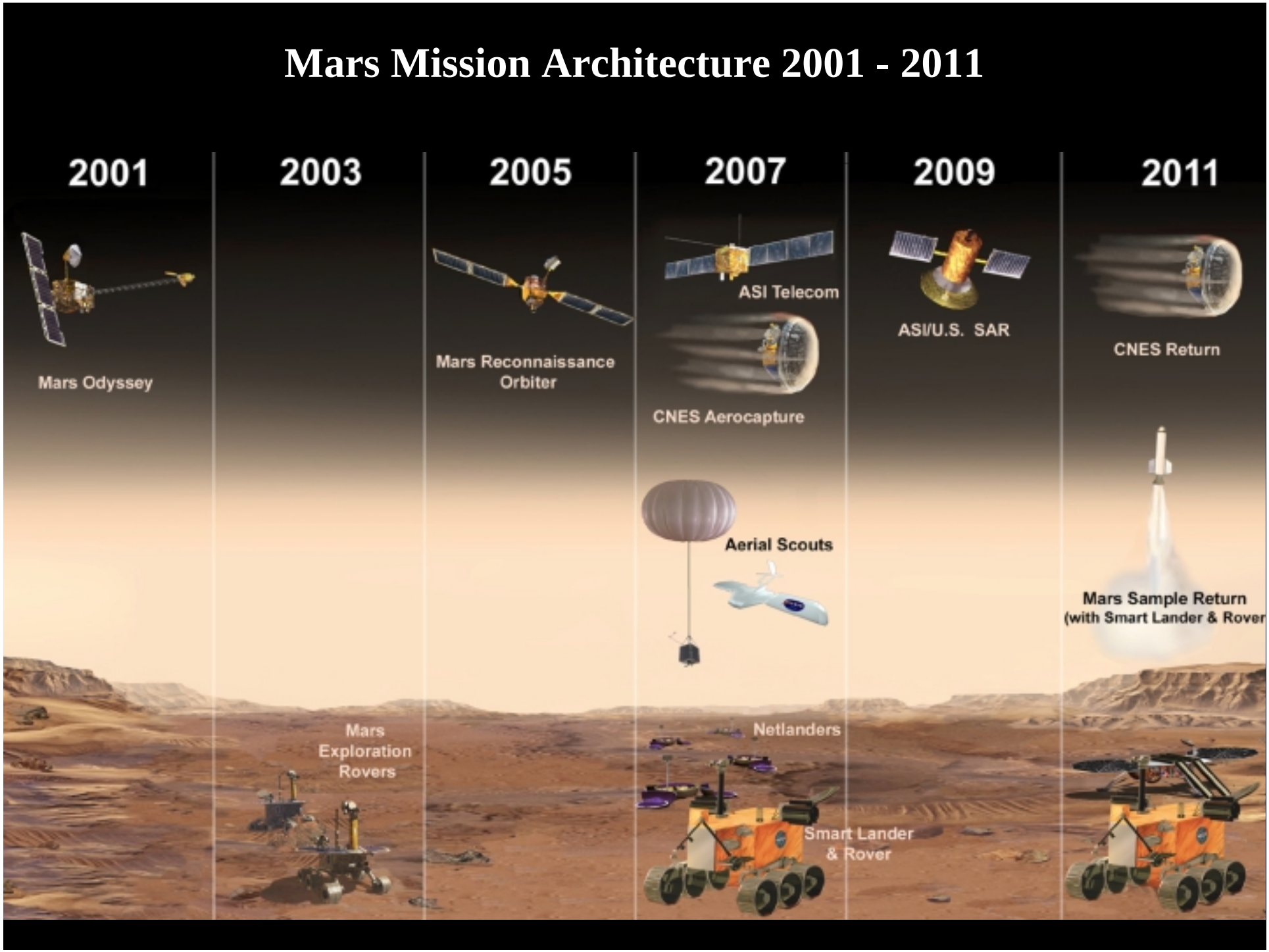


Outer Planets Program:
Exploring Organic-Rich Environments

Discovery Program:
Partnerships for Innovation

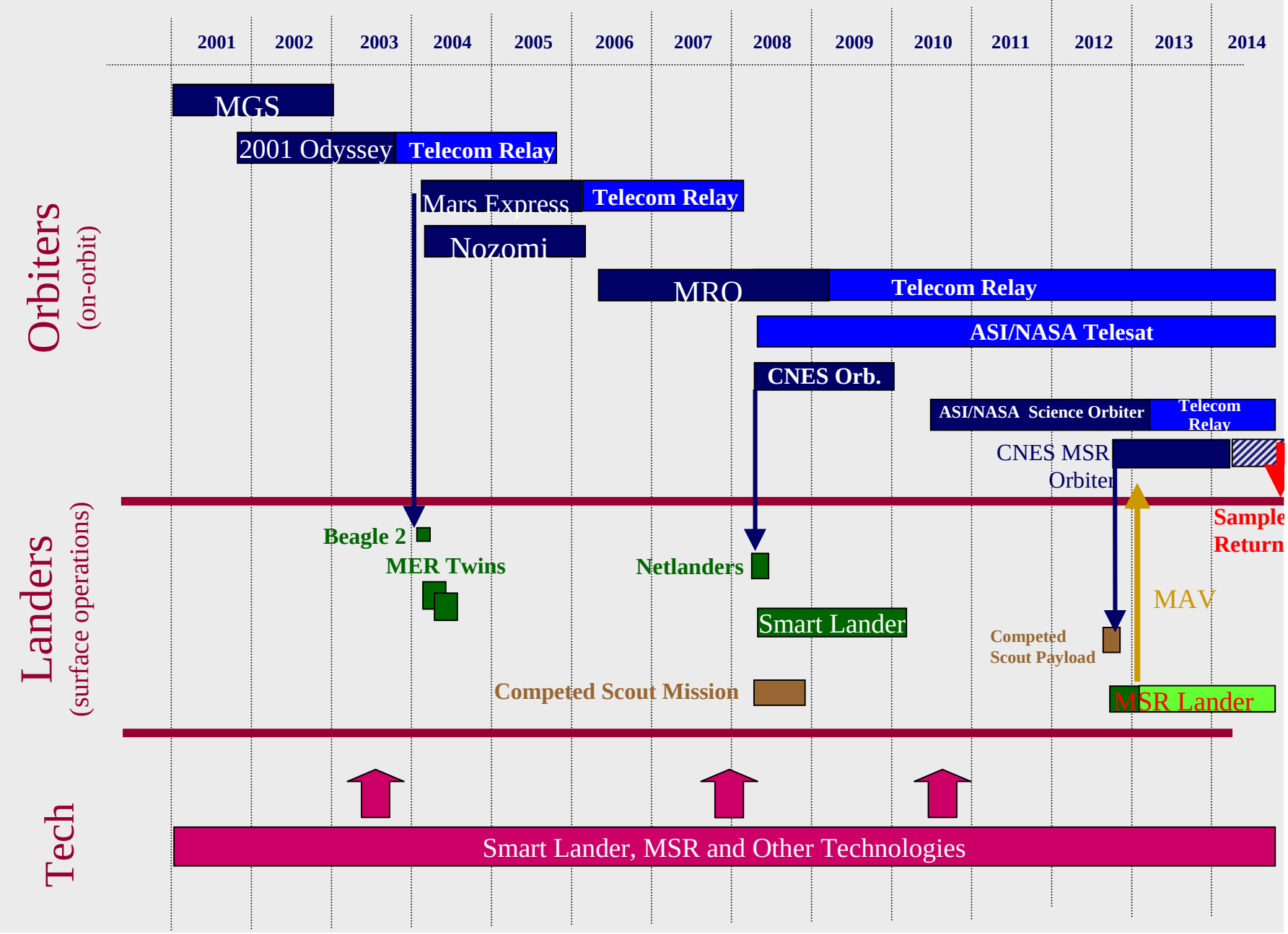
Proposed New Initiative -To Build a Planet:
Formation and evolution of planetary environments

Mars Mission Architecture 2001 - 2011



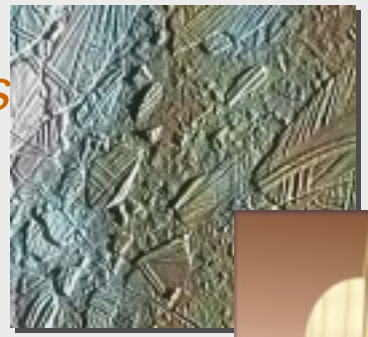
MARS EXPLORATION PROGRAM

Mars Mission Timeline

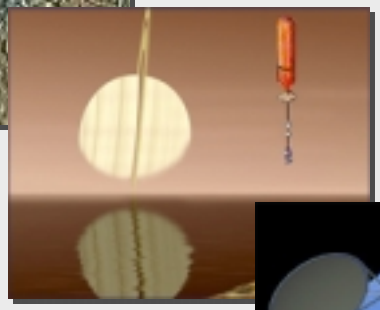


Outer Solar System Exploration

Outer Planets Program: Exploring Organic-Rich Environments

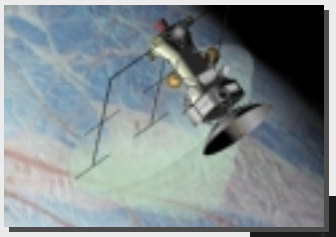


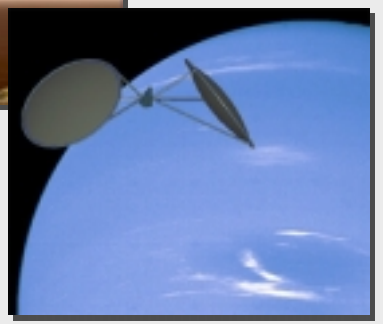
Europa Lander



Titan Explorer

Europa Orbiter

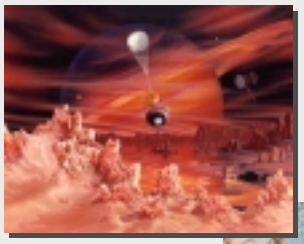


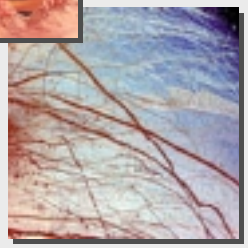


Neptune Orbiter

Pluto/Kuiper Express

Cassini/Huygens



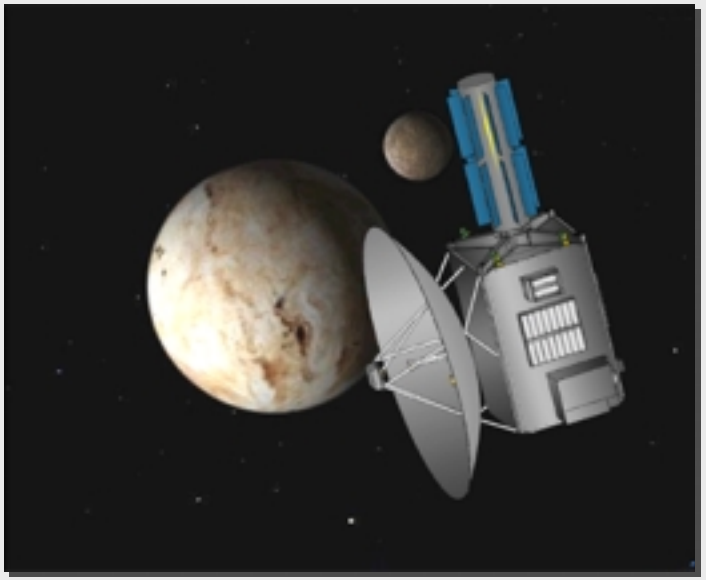


Galileo-Europa

Solar System Exploration

Annual Report 2000

Pluto-Kuiper Express



Mission Study Parameters

Trajectory Type	SEP or Gravity Assist
Launch Date	TBD
Arrival Time	<2020
Flight Time	8-10 yrs
Launch System	EELV/Star-48

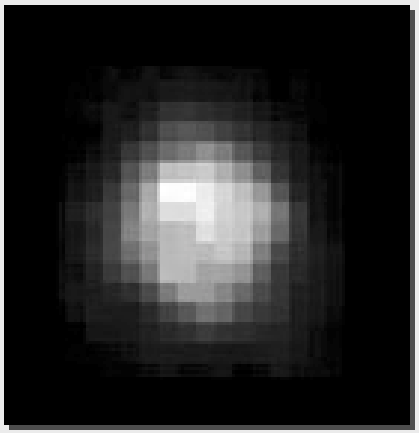
EELV = Evolved Expendable Launch Vehicle

Objectives:

- Geology of Pluto and Charon
- Maps of surface composition and atmospheric structure
- First images of Kuiper objects

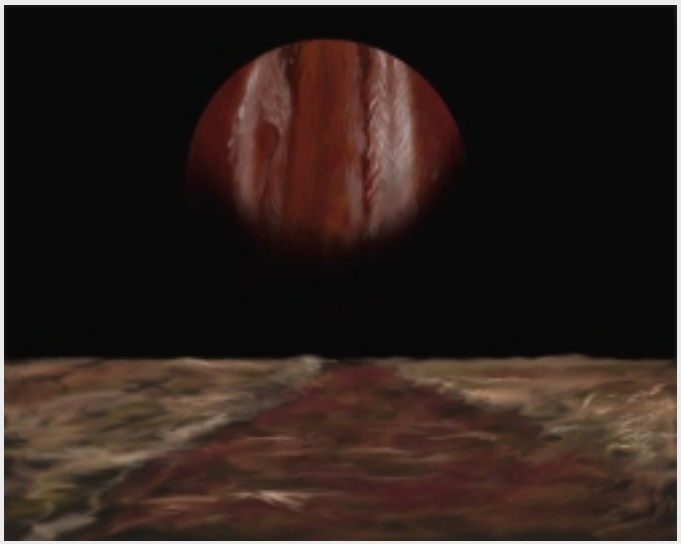
Strawman Investigations

- Imaging
- IR Mapping Spectrometry
- UV Spectrometry
- Radio Science Uplink Occultation



Best image of Pluto to date

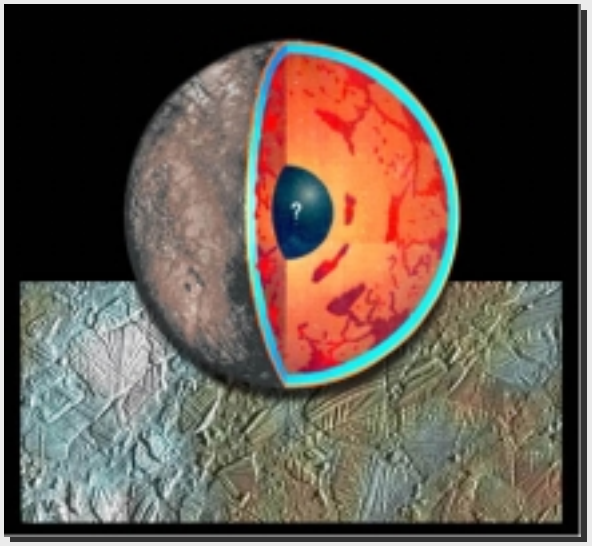
Exploring Europa: Beyond Europa Orbiter



Europa may one day become a target for a comprehensive "Mars-like" exploration program.

- ***Critical Questions***
  - What is the age and composition of the Europa surface?
  - What organic chemical processes are taking place?
  - Is there potential access to liquid water?
  - Are there any indications of pre-biological activity?
  - Is there life?

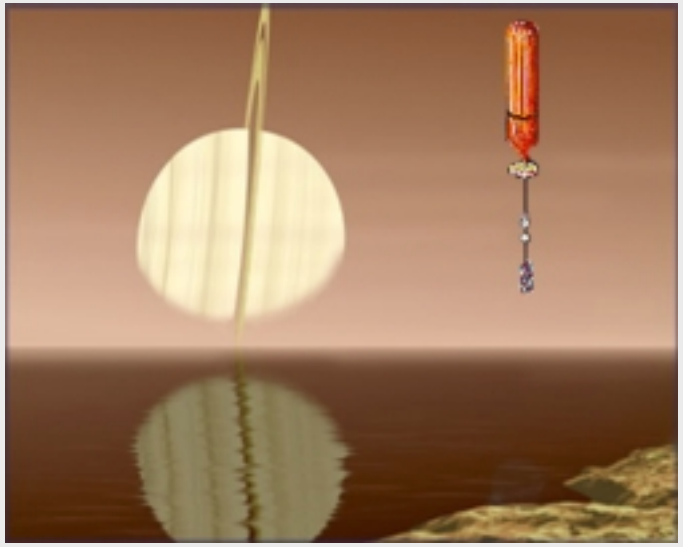
- ***Key Capabilities***
  - High performance, low mass propulsion for descent
  - Autonomous landing and hazard avoidance
  - Miniature organic chemistry laboratories
  - Sample acquisition & processing
  - Bioload reduction
  - Radiation tolerant components
  - Ice penetration and mobility



Potential Elements of a Europa Exploration Program

- Europa Orbiter
  - Detect and characterize global water and examine surface ice
- Surface experiments: Science and technology pathfinders
  - Carried by Europa Orbiter?
  - Coordinated with Europa Orbiter?
  - Impactors, penetrators, “Ranger”-like imagers, “Scout” survivable landers
  - Characterize surface, demonstrate capabilities, examine landing sites
- Soft landers and mobile science stations
  - Detailed surface structure and chemistry
- Subsurface exploration: Ice and/or water mobile platforms (“Cryobots”)
  - Detailed subsurface chemistry
  - Search for indicators of prebiotic chemistry or past or present life
- Sample return from the surface or subsurface

Titan Exploration: Beyond Cassini/Huygens



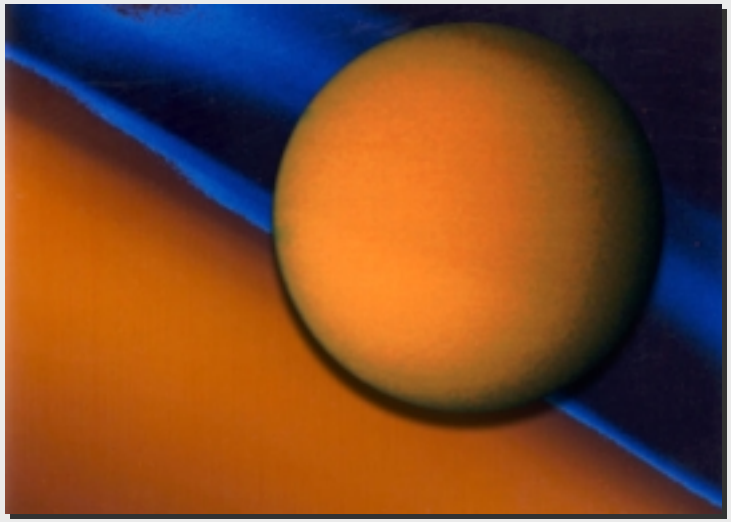
Titan may bridge the gap between life's chemical building blocks and more evolved environments such as Earth and Mars.

Critical Questions

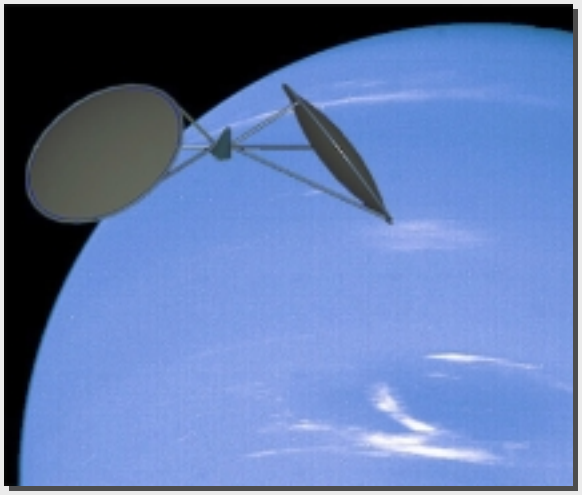
- What prebiotic chemistry is taking place at Titan and what can it tell us about the primordial Earth…and the origin of life?
- What is the composition of Titan's surface and how does it interact with the atmosphere?
- How has Titan evolved over its history?

- Atmospheric and surface measurements
- Aerial platforms, landers, surface rovers
- Atmosphere and surface sample return

- ***Key Capabilities***
  - Balloon or aircraft mobility
  - Aerocapture at Titan
  - Miniature *in situ* chemistry lab
  - Sample acquisition
  - Bioload reduction
  - Advanced propulsion

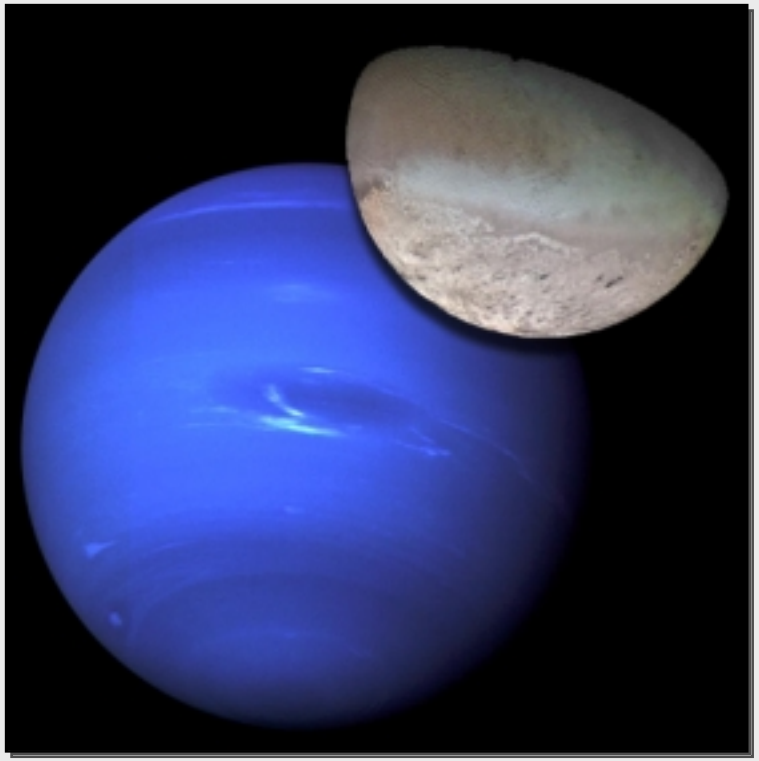


Neptune Orbiter Mission



- ***Critical Questions***
  - What is Neptune's atmospheric structure and chemistry? What is the structure and behavior of its magnetosphere?
  - What are Triton's physical properties? Is it a captured Kuiper object? What can it tell us about the formation and evolution of the far outer solar system?
  - What are the dynamics of the rings and satellites?

- Ready for mission start: 2006-2007
- 10 year flight to Neptune, 2-4 year orbital tour
- Multiple flybys of Triton and sampling of upper atmosphere



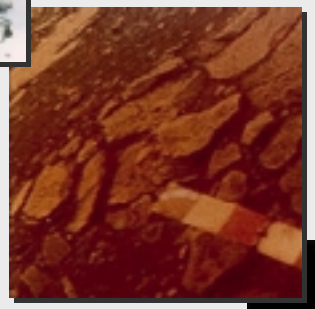
- ***Key Capabilities***
  - Aerocapture
  - Advanced telecommunications system
  - High-power solar electric propulsion
  - Autonomous spacecraft operations
  - Temperature tolerant electronics

Proposed New Initiative: *To Build a Planet*

To Build a Planet:
Formation and evolution of planetary environments

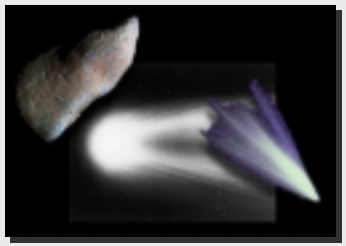
Comet Nucleus Sample Return

Venus Sample Return

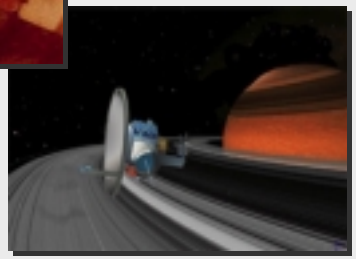


MESSENGER

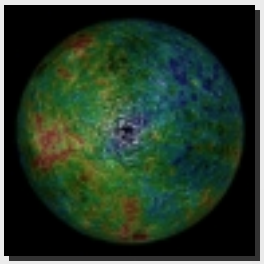
Primitive Bodies Missions



Saturn Ring Observer



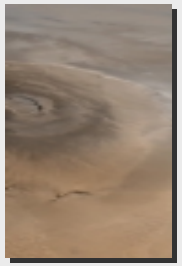
Lunar Prospector



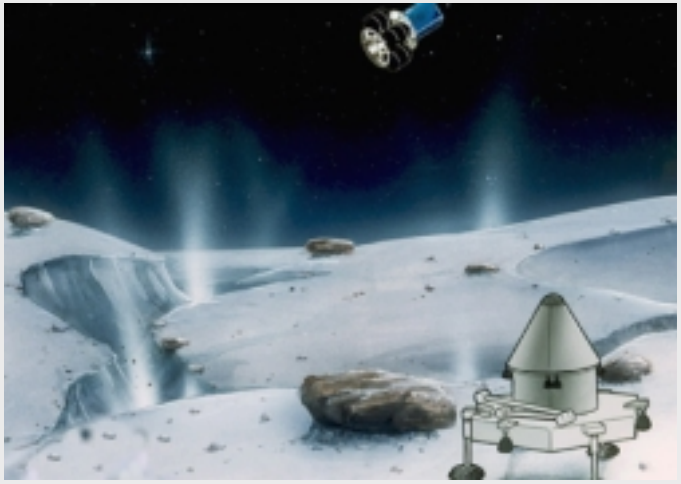
Magellan

Mars Surveyor

Mars Surveyor



Comet Nucleus Sample Return



- Mission duration 6 to 10 yrs
- Launch opportunities every year
- Solar electric propulsion

- ***Key Capabilities***
  - Comet sample acquisition and handling
  - Improved solar electric propulsion
  - Autonomous control and navigation
  - Precision guidance and landing
  - High-efficiency solar arrays
  - High velocity Earth entry system

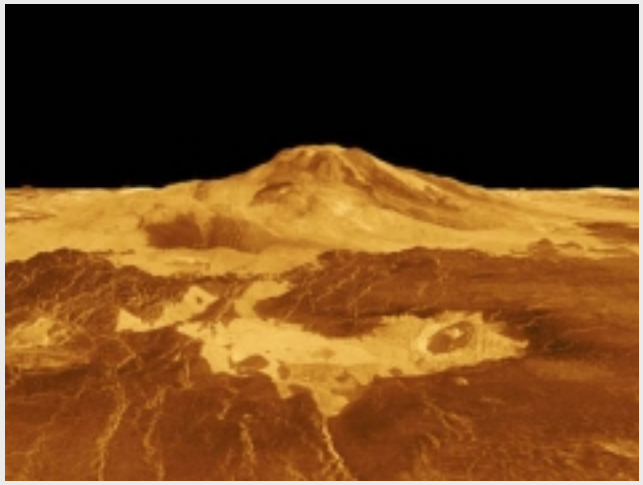
Critical Questions:

- What is the chemical composition of pristine comet nucleus material? What does it tell us about the primordial solar system?
- How have comets evolved since their formation? How does their composition vary with depth and location on the nucleus?
- What can we learn about the likely effects and mitigation of cometary impacts?

Trade Studies FY00

S/C Architecture:	Single vs Dual
Mission Design:	Full SEP, BiProp Return, G/A for sample insertion
Mission Factors:	Dust Mitigation Telecom scenarios Site Selection

Venus Exploration: Surface Sample Return

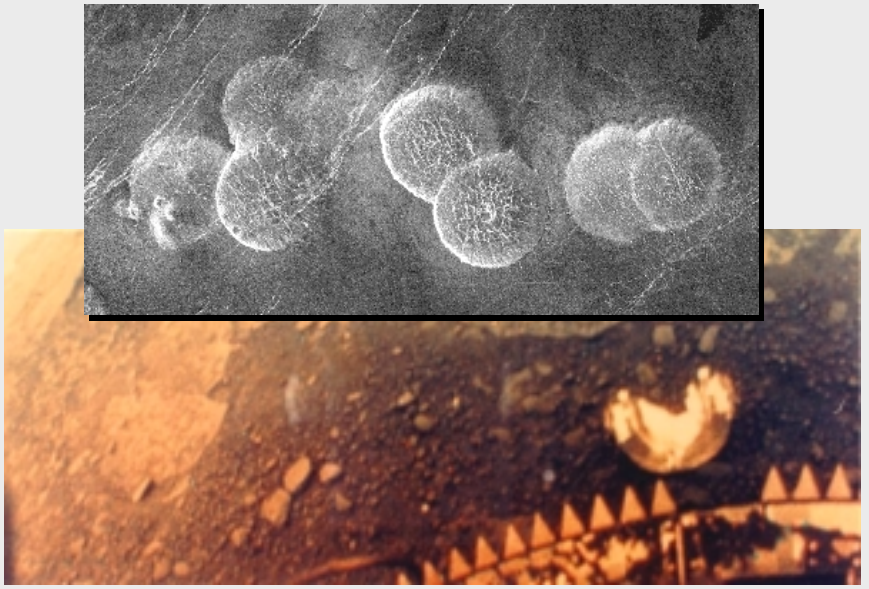


Critical questions

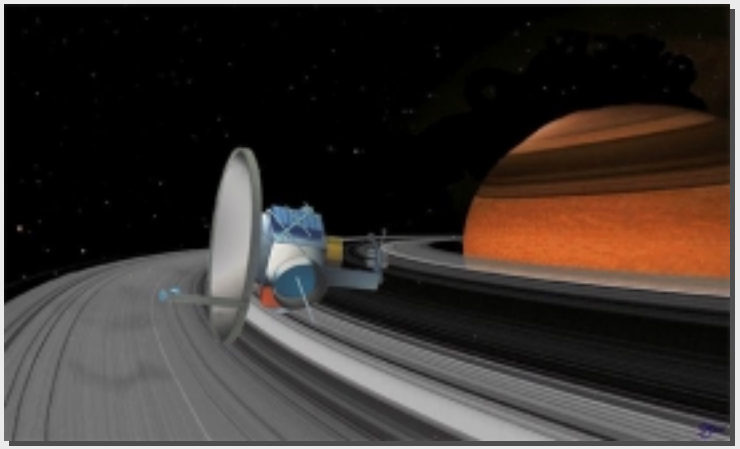
- What is the age and chemical composition of Venus' surface? What is its atmospheric composition?
- Why did Venus and Earth take such different evolutionary pathways?
- Was there ever liquid water on Venus? Where did it go?
- What can Venus tell us about the future of planet Earth?

- Tech readiness possible by 2006-2007
- Short-duration surface stay time (~90 min)
- Balloon/rocket ascent
- Significant use of Mars Sample Return technologies
- Precursor missions likely

- ***Key Capabilities***
  - Aerocapture
  - High temperature balloon system
  - Thermal control
  - Sampling mechanisms

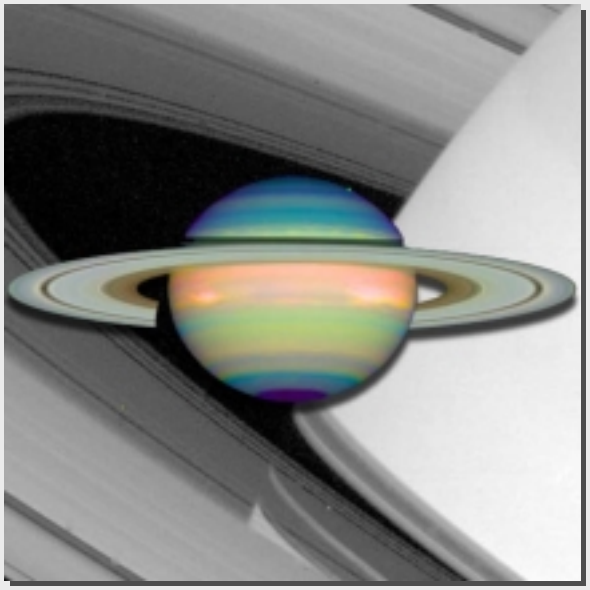


Saturn Ring Observer



- Ready for mission start: 2006-2007
- Aerocapture into close Saturn orbit
- Co-rotating, “hovering” orbit approx. 3 km above ring plane
- 30 days in close ring orbit

- ***Critical Questions***
  - What are the physical properties of the icy particles comprising Saturn’s rings?
  - What do their detailed, time-varying interactions tell us about the evolution of Saturn’s rings?
  - What does the detailed study of Saturn’s rings tell us about the early stages of planet formation and the present-day dynamics of extra-solar disks, accretion disks, and spiral galaxies?



- ***Key Capabilities***
  - Aerocapture
  - Advanced propulsion: SEP or solar sail
  - Low mass, high-efficiency chemical propulsion
  - Autonomous navigation and maneuvers

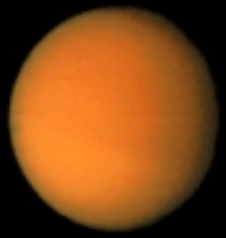
Recommended Missions

*Near-term and Mid-term** (2003-2007) (2008-2013)	*Far-term (2013 and beyond)*
Mars Exploration Program (Continuing)	
Mars Sample Handling and Analysis (Top New Priority)	Intensive site exploration
Mars Subsurface Exploration	Advanced outposts
Mars Robotic Outposts	Deep coring and search for extant life
Earth-Mars Internet	
Outer Planets Program (Continuing)	
Europa Lander	Robotic outposts and sample returns
Titan Explorer	Kuiper Belt exploration
Neptune Orbiter/Triton Flybys	Interstellar precursors
Discovery Program (Continuing)	
Competitively Selected Missions	Advanced Studies of Planet Formation and Evolution
To Build a Planet (Proposed new program)	
Comet Nucleus Sample Return (Top Priority New Mission)	Sample all types of bodies
Venus Sample Return	Deep atmospheric probes
Saturn Ring Observer	Explore large asteroids/protoplanets

* Approximate mission start dates

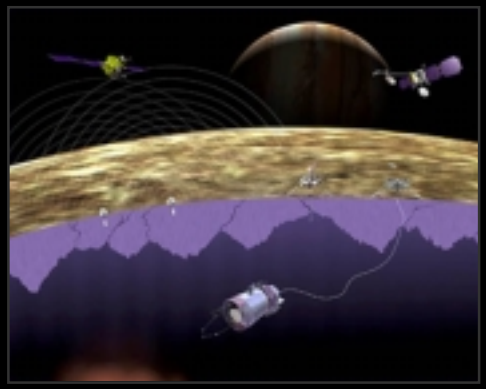
Exploring Organic-Rich Environments: Future Concepts

Triton Lander

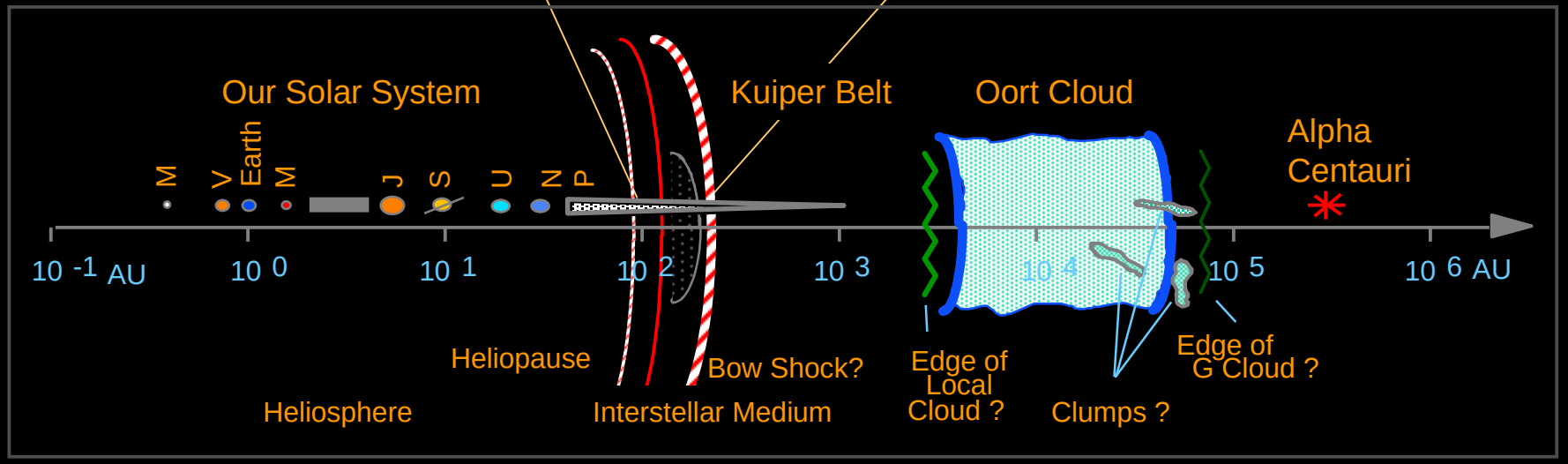


Outer Planet Satellite Sample Returns

The Kuiper Belt and Interstellar Exploration



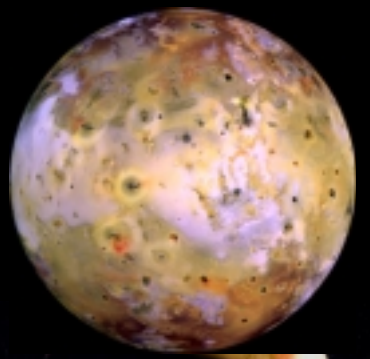
Europa Ocean Science Station



To Build a Planet: Future Concepts

Monitor planetary climate change: Venus Robotic Outposts

Future missions will focus on the detailed exploration of harsh planetary environments and on the return to Earth of samples from all types of bodies



Observe active geological processes: Io Volcanic Observer

Return samples from throughout the solar system